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Impulsivity and negative priming: Evidence for diminished cognitive inhibition in impulsive children

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This study addresses the relationship between impulsivity and lack of inhibition. Inhibition was measured both by the interference score and by the negative priming effect in a Stroop colour-word paradigm. The negative priming effect in this paradigm is defined by slower naming of a target colour if this colour was the distractor in the immediately preceding trial.

For the study, a total of 210 school children were selected. These were children rated high or low by their teachers for either social or cognitive impulsivity. A reduced negative priming effect showed up with social type but not with cognitive type impulsive children. No differences were found regarding the Stroop interference score. The divergence between negative priming and interference as a measure of inhibition was discussed. Overall, the findings corroborate the distinction between a cognitive and a social dimension of impulsivity.

Impulsivity and lack of inhibition

Impulsive behaviour can be characterized as sometimes excessive, action-oriented behaviour (Barratt, 1987; Barratt & Patton, 1983). This tendency to action is often attributed to deficient inhibition (e.g. Kagan, Rosman, Day, Albert & Phillips, 1964; Soppe, 1979). The issue raised here, however, is whether this hypothesized relationship between impulsivity and inhibition does indeed exist. In studying this question, we will focus on the cognitive level of behaviour.

In spite of its seeming obviousness, the amount of research on the relationship between impulsivity and cognitive inhibition is not overwhelming. Nevertheless, some studies have been conducted on this subject. Boyden & Gilpin (1978), for example, found a positive correlation between errors on the usual laboratory measure of impulsivity, the Matching Familiar Figures Test (MFFT; Kagan *et al.*, 1964), and on the Stroop task, which can be considered as a measure of cognitive inhibition. However, because both Stroop (White, Moffitt, Caspi, Bartusch, Needles & Stouthamer-Loeber, 1994) and MFFT errors showed a negative correlation with IQ (Milich & Kramer, 1984), the absence of IQ as a control variable in Boyden & Gilpin's study hampers an interpretation of their results. Barratt & Patton (1983) reported that impulsivity, as measured with the Barratt Impulsivity Scale, goes along

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with slower reaction times on the Stroop task. This result seems to be an argument in favour of a negative relationship between impulsivity and cognitive inhibition. Unfortunately, however, the Barratt & Patton study is not described in any detail. Therefore, the significance of their results remains unclear. A third study on the relationship between impulsive behaviour and Stroop performance was conducted by White *et al.* (1992). They found errors on the Stroop task to be a main determinant of a factor which they called 'cognitive impulsivity'. Again, this result would fit perfectly into a 'response inhibition deficit' hypothesis. However, it can be questioned whether cognitive impulsivity was indeed the most appropriate label for this factor. Actually, the factor comprised all laboratory tests administered in this study, whereas a second factor contained all questionnaire measures. One study did not support the cognitive inhibition hypothesis of impulsivity. Dickman (1985) found impulsive subjects, as defined by a shortened form of the Eysenck Personality Inventory, to be as adequate as non-impulsive subjects in handling Stroop-like incompatible information.

In summary, there are some indications that impulsivity indeed coincides with deficient cognitive inhibition. However, the interpretation of these results is not straightforward. One study does not support the hypothesis (Dickman, 1985). The conclusion is that, mainly because of the lack of solid studies on the subject, the relation between impulsivity and cognitive inhibition is in need of further investigation.

Cognitive inhibition: Interference and negative priming

In all the studies mentioned above cognitive inhibition was operationalized by means of the interference effect in a selective attention task. The interference effect is achieved by presenting a target stimulus together with a distractor, and by asking the subject to react as quickly as possible to the target, thereby ignoring the distractor. The presence of the distractor causes interference, which can be measured by an increase in reaction time. A well-known example of a task measuring interference is the Stroop task. In this task the ink-colour of a word has to be named, while the word itself indicates a different colour (e.g. MacLeod, 1991).

Recently, however, another related operationalization of cognitive inhibition has been suggested. This is the so-called negative priming effect (e.g. Beech, McManus, Baylis, Tipper & Agar, 1991; Dalrymple-Alford & Budayr, 1966; Tipper, 1985). Negative priming refers to an increase in reaction time to the target in an interference trial if this target was the distractor in the trial immediately preceding. Thus, for example, in the Stroop paradigm, colour naming is slower if the colour corresponds to the preceding distractor word. Like interference, negative priming appears to be a very persistent phenomenon. The effect has been demonstrated in a wide variety of selective attention tasks (Tipper, Weaver, Cameron, Brehaut & Bastedo, 1991*a*; Tipper, Weaver, Kirkpatrick & Lewis, 1991*b*).

However, compared with the interference effect, the negative priming effect seems to have an additional advantage as a measure of interference. There are indications that its diagnostic power exceeds that of the normal interference effect. For various groups of people who can be expected to have inhibition problems, such as

schizophrenics, reduced negative priming was found, whereas interference scores failed to show a difference with control groups (Beech & Claridge, 1987; Tipper & Baylis, 1987). The reverse was never found. Thus far, reduced negative priming has been shown with elderly people (Hasher, Stoltzfus, Zacks & Rypma, 1991; Stoltzfus, Hasher, Zacks, Ulivi & Goldstein, 1993), young children (±eight years; Tipper, Bourque, Anderson & Brehaut, 1989), schizotypes (Beech, Baylis, Smithon & Claridge, 1989; Beech & Claridge, 1987), schizophrenic patients (Beech *et al.*, 1991; Beech, Powell, McWilliam & Claridge, 1989), and with people with high scores on the Cognitive Failures Questionnaire of Broadbent *et al.* (Tipper & Baylis, 1987).

Measuring impulsivity: The VIS

Little consensus exists about how to measure impulsivity. Some laboratory measures are commonly used (Kagan *et al.* 1964; Milich & Kramer, 1984), such as the MFFT. However, their validity is definitely questionable (e.g. Block, Block & Harrington, 1974). Also, questionnaires have been developed (e.g. Barratt, 1987; Eysenck, Pearson, Easting & Allsop, 1985). From these, it appears that impulsivity is not a unidimensional trait. Subcomponents can be distinguished. However, the number and nature of the components that should be distinguished are not entirely clear.

In this study we will not go further into this problem of assessment. Some conclusions regarding this question are presented in Visser (1993). Because of the research frame in which the present study took place, i.e. a study on impulsivity problems among elementary school children (Visser, 1993), our interest was in impulsivity as experienced by teachers. We constructed a teacher rating scale using the prototype method, based on teachers' ideas of impulsivity (Visser Impulsivity Scale (VIS); Visser, Das-Smaal & Feij, 1993). In developing this scale it appeared that two types of impulsivity were distinguished by the teachers, a social and a cognitive one. The social type of impulsivity refers to a kind of hyperreactivity. Children with high scores on this aspect always talk before their turn, react to all kind of things that happen in the classroom, and so on. The cognitive type of impulsivity refers to an impulsive working attitude. Children with high scores on this aspect do not analyse their work before starting it, and do not listen to instruction, for example. Using the VIS, both aspects of teacher-defined impulsivity can be measured.

The present study: Impulsivity and cognitive inhibition

Taken together, impulsivity is often regarded as behaviour that is characterized by lack of inhibition. Evidence on this matter, however, is scarce and inconclusive. In this study we will test the hypothesis of decreased cognitive inhibition in impulsive children. Regarding the concept of impulsivity, a distinction will be made between social and cognitive impulsivity, as operationalized by the VIS. The negative priming effect will be employed as a measure of cognitive inhibition. This is a relatively new, potentially powerful operationalization of response inhibition. In addition, the more usual operationalization of cognitive inhibition, i.e. the interference effect, will be measured.

Sex, age and IQ will be controlled, because it has been shown that impulsivity related disorders were unevenly distributed over the sexes (DSM III–R; American Psychiatric Association, 1987), and because age (Achenbach & Weisz, 1975) and IQ (Milich & Kramer, 1984; Paulsen & Arizmendi, 1982) can also confound the interpretations of impulsivity.

Method

Subjects

Subjects in this study were 210 high and low impulsive children selected from 771 fifth form children in 38 primary schools in the west of The Netherlands. For selection purposes, the 771 children were rated by their own teacher on both the social and the cognitive impulsivity scale of the VIS (Visser *et al.*, 1993). Subjects who scored either high or low on either the cognitive or the social component of impulsivity were selected for participation.

Two criteria were applied: (*a*) a score in the upper or lower third of the distribution on either the cognitive or the social impulsivity dimension, and (*b*) a score between the upper and lower third of the distribution on the other impulsivity dimension.

An additional requirement was imposed, namely that the children spoke the Dutch language at home. Following selection, examination of the characteristics of the high cognitive impulsivity group showed that nine subjects were rather old for the fifth form. To prevent this factor from influencing the results, all children whose age was more than two standard deviations from the mean age of the total group of children selected were excluded; there were nine children from the high cognitive impulsivity group and one from the low social impulsivity group. Table 1 gives group size, mean age and percentage of girls in the four groups of subjects.

Table 1. Group sizes, age (mean and SD) and percentage of girls for the different levels of cognitive and social impulsivity

	Cognitive impulsivity				Social impulsivity			
		Age (months)				Age (months)		
	N	Mean	SD	% girls	*N*	Mean	SD	% girls
Low impulsive	50	130.3	3.9	48	47	131.2	4.3	75
High impulsive	48	132.3	4.7	63	65	131.9	4.1	35

Materials

Stroop task. A computerized version of the Stroop task was used. As in the standard version (e.g. Hammes, 1978), three different conditions were presented to the subject. The first two conditions are preparatory to the third interference condition and concern a word-reading and a colour-naming condition, respectively. In the word-reading condition stimuli were the single words 'blue', 'red', 'green' or 'yellow', written in a standard grey ink-colour. The subject was instructed to read the word as quickly as possible without making errors. In the second condition the colour word was substituted by a colour patch, using the same four colours as mentioned above. The third condition, interference, combined both preparatory conditions. Again, a colour word was presented, but this time the ink-colour was incompatible with the word. For example, the word yellow was written in green ink. The subject had to name the colour.

Unlike the standard version of the Stroop task, in the third condition the trial sequence was manipulated such that a mix of three priming conditions was effected: (1) in 32 trials the target equals the distractor of the preceding trial (negative priming); (2) in 35 trials the distractor equals the target

of the preceding trial (distractor priming); (3) in 33 trials no relation with the preceding trial was present (no priming). A fixed order of presentation was used to present the mix of three priming conditions. Ten exercise trials were given.

With respect to the preparatory conditions, both the word-reading condition and the colour-naming condition consisted of 48 trials and both were preceded by eight exercise trials.

Response time was recorded per trial using a voice-key. All answers were written down directly by the tester and were recorded on tape. Stimulus presentation was preceded by a fixation cross, which appeared on screen for 500 ms. The stimulus itself remained on screen until a response was given. Following the response, a 500 ms pause was given before the next trial started.

IQ test. Time constraints prevented the administration of a complete IQ test battery. Therefore, subtest for verbal and performance IQ was selected on the basis of their reliability scores and t relatively high correlation with total IQ (Bleichrodt, Drenth, Zaal & Resing, 1987). These subtests a described below.

Test for verbal IQ. The subtest 'Verbal meaning' from the Amsterdam Revised Intelligence Scale for Children (RAKIT; Bleichrodt *et al.*, 1987) was used to test verbal IQ. In this test the experimenter names a word and shows a piece of cardboard with four drawings on it. The subject has to point to the drawing that fits best with the word. The test is intended to measure passive word knowledge.

Test for performance IQ. The subtest 'Exclusion', also derived from the RAKIT, was used to test performance IQ. In this subtest, four pictures are shown to the subject. Three pictures can be grouped according to a to-be-discovered principle, one picture has to be excluded. The subject is required to point out the picture that does not form a category with the other pictures. This subtest requires logical reasoning capacity.

Procedure

The test sessions took place about two months after the subjects were selected. Testing was done in a quiet room at school. Subjects were tested on an individual basis. As this study was part of a larger study, other tasks were administered (Visser, 1993) in addition to the Stroop task and the IQ subtests. The Stroop task was presented on an Olivetti PCS 286 with a video-screen. Subjects were seated about 100 cm from the screen and instructed by computer to react quickly but to make as few errors as possible. Stroop task administration took 15 minutes, the verbal IQ subtest 'Verbal meaning' five minutes, and the performance IQ subtest 10 minutes. Together with the other tasks (Visser, 1993), the total test session took about 55 minutes. After the tests the subjects received a small gift.

Analyses and results

Median reaction times for correct responses were analysed within a multivariate model of variance by way of planned contrasts, with condition as a four-level within-subject variable and impulsivity as a four-level between-subject factor. Condition levels concerned negative, distractor and neutral priming, and the 'name colour' condition. Levels of impulsivity were high and low on either social or cognitive impulsivity. Scores on the IQ subtests and age were taken as covariates, whereas sex was added as a two-level between-subject factor. The planned contrasts concerned the traditional Stroop interference score, determined by contrasting the three priming scores with the baseline 'name colour' condition, and the negative and the distractor priming scores, derived by contrasting these conditions with the neutral priming condition. With respect to distractor priming, results will be reported

without further discussion. This condition is not the main focus of this article and was included for explorative purposes only.

Inhibition errors (reading the word instead of naming the colour) were selected from all other errors resulting from factors that triggered the voice-key (coughing, sighing and saying other things). Following this procedure, however, too few errors remained in each condition to allow proper analysis. Therefore, the decision was made to analyse the inhibition errors for the three priming conditions together. In all other ways the error analysis was identical to the analysis described above.

The Stroop interference effect ($F(1, 199) = 1319.62$, $p < .001$), and both the negative ($F(1, 199) = 259.80$, $p < .001$) and distractor priming effects ($F(1, 199) = 56.88$, $p < .001$) were highly significant. An interaction was found between social impulsivity and negative priming ($F(1, 199) = 13.95$, $p < .001$). As expected, high social type impulsive children showed less negative priming than low social type impulsive children (see Table 2). For cognitive impulsivity such a relation was not present. No interactions with the Stroop interference were encountered. The negative priming effect appeared to be sex dependent. Girls showed smaller effects than boys ($F(1, 199) = 6.31$, $p < .05$). To a lesser degree this effect of sex tended to turn up with distractor priming ($F(1, 199) = 3.77$, $p < .06$). No group effect on errors was found.

Table 2. Means of median reaction times (in ms) for the 'read word', the 'name colour', the no priming, the negative priming, and the distractor priming condition, and the mean number of Stroop inhibition errors by high and low cognitive (Cogimp) and social impulsivity (Socimp)

	Word	Colour	No priming	Negative priming	Distractor priming	Inhibition (errors)
High Cogimp	585±57	699±83	1029±154	1142±210	1093±200	3.0±3.4
Low Cogimp	563±64	678±82	961±143	1067±167	998±193	2.9±2.7
High Socimp	567±63	677±86	975±159	1046±160	1030±203	3.1±2.6
Low Socimp	576±68	679±93	974±150	1095±251	1033±197	3.6±3.1

Discussion

In this study we tested the hypothesis of reduced cognitive inhibition for impulsive children using the negative priming effect and the Stroop interference effect. Results demonstrated a diminished negative priming effect for one of the two types of impulsivity that were measured, i.e. the social impulsivity component. Cognitive type impulsive children did not show any difference in negative priming. The traditional Stroop interference effect did not discriminate among groups.

The fact that negative priming differentiated between high and low social type impulsive children, whereas the interference effect failed to show any differences, might be taken as evidence that negative priming is a more sensitive measure for detecting individual differences in cognitive inhibition than the interference effect.

One could argue, however, that the interpretation of the interference effect in this study is questionable. As the interference effect was determined by contrasting the interference condition with the 'name colour' preparatory condition, as in the traditional Stroop task, this effect might be confounded with temporal variables acting differentially on the various levels of impulsivity. For example, one could imagine that highly impulsive children profit less from practice in the preparatory condition, or tire more quickly. However, because no differences among the high and low social impulsivity groups were found either on the baseline or on the interference condition, this interpretation seems improbable with respect to social impulsivity. Also, for cognitive impulsivity no significant differences were found on interference and on baseline conditions. However, apart from the inhibition issue, Visser (1993) found another effect for cognitive impulsivity. There was a tendency for high cognitive type impulsive children to be slower than low cognitive type impulsive children. This tendency was quite stable over Stroop conditions and even over different tasks, varying from simple reaction time tasks to complex concept learning tasks (Visser, 1993). Again, it seems improbable that this difference confounded the interpretation of interference and negative priming effects.

That negative priming is a more promising measure of cognitive inhibition than interference was touched upon in the introduction. Various groups of people with presumed inhibition problems have been shown to exhibit reduced negative priming but not lowered interference scores. In the present study, again a differentiation between the negative priming and the interference effects was found. This brings us to the intriguing question concerning the similarities and differences between these effects. In the next part of the discussion an attempt will be made to unravel both effects.

Although the interference and the negative priming effects apparently can diverge, they are certainly connected. The occurrence of a distractor stimulus in the preceding trial is even a prerequisite for negative priming to occur in the current trial. However, any further relation between both effects does not appear to be obvious (e.g. Stoltzfus *et al.*, 1993; Tipper *et al.* 1991*b*). The seeming independence between the size of the two effects (e.g. Stoltzfus *et al.*, 1993) and also the relatively late onset of negative priming as a consequence of interference (Yee, 1991) raise the suspicion that inhibition, as measured with the negative priming effect, has little to do with the mechanism that deals with interference. Rather, negative priming seems to refer to an independently functioning, centrally located process (Tipper *et al.*, 1991*b*), that might even start just after interference problems have been overcome (Yee, 1991).

The functionality of such an inhibition mechanism has some face value. It seems to help the individual to profit from earlier selections. Our world is full of distractors and many of them are constantly present. If one would have to make the same selections over and over again, information processing would be rather inefficient. A kind of 'memory' for selection might be of great help in tackling all information impinging on us. Globally, this idea has been proposed by Stoltzfus *et al.* (1993). They consider negative priming to be an inhibition phenomenon that enables us to keep thoughts suppressed that were already rejected.

Returning to the results in the field of individual differences, it seems that in particular this late inhibitory function, but not the mechanism that deals with

interference, is affected in groups of people showing a lack of behavioural inhibition. Embroidering on the 'thought selection' explanation of Stoltzfus *et al.* (1993), schizophrenics, schizotypes, old people, young children, social type impulsive children and people with high scores on Broadbent's Cognitive Failures questionnaire will be especially susceptible to the nuisance of interfering thoughts.

The notion of negative priming as an inhibition phenomenon, functioning separately from the mechanism that solves interference, is quite interesting. It reopens the question of whether interference relies on active inhibition at all. In fact, data on temporal aspects (Yee, 1991) and on the divergence between interference and negative priming effects in groups of people that are expected to have cognitive inhibition problems (Beech & Claridge, 1987; Tipper & Baylis, 1987), suggest that this is not the case. If so, this brings all research using the interference effect as a measure of cognitive inhibition into question. Negative priming may offer an alternative measure. Presently, in our laboratory we are elaborating on the mechanisms underlying this effect.

The results of the present study also demonstrate the importance of distinguishing between subgroups of impulsivity in testing characteristics of impulsivity. As stated before, impulsivity is not a unidimensional trait. Various subtypes can be distinguished. The current study focused on dimensions of impulsivity as distinguished by elementary school teachers, i.e. social and cognitive impulsivity. The study indicated that these dimensions do not coincide with the same cognitive processing features. High social impulsive children showed a reduced negative priming effect compared with a contrast group that scored low on the social impulsivity scale. Cognitive impulsive children did not show any relation with either interference or negative priming. However, there was a tendency for high cognitive type impulsive children to be slower in their reactions than low cognitive type impulsive children. Which other dimensions of impulsivity need to be discriminated and whether or not these show a relation with inhibition or other facets of cognitive processing remain issues for further study.

In summary, impulsivity is a personality trait that has been suggested as being linked with inhibition problems. In this study we found evidence that one type of impulsive children, i.e. social type impulsive children, have a diminished negative priming effect, which is a purported measure of inhibition. This might point to less inhibition with social type impulsive children. In that case one would have to assume that negative priming is a more indicative measure for inhibition than the interference effect, because here no differences were found. In the discussion it was reasoned that diminished negative priming could be explained as referring to an inhibition mechanism functioning separately from interference. Another group of impulsive children, the cognitive type impulsive children, failed to show any difference on either interference or negative priming. Together, the findings corroborate the distinction between a cognitive and a social dimension of impulsivity.

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